

How a science education course can influence early childhood teachers' attitudes toward science?

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Abstract

While early childhood teachers' professional training is vital for preschoolers, the training is less centered on science than it is on interpersonal behavior, languages, reading, writing, and arithmetic. Courses regarding children's science education are neither common nor popular in Taiwan's present training for early childhood teachers. Consequently early childhood teachers lack the proper knowledge and training to introduce science to preschool children. The Center for Teacher Education at Yuan Ze University created a science education course for student teachers, entitled "Children's Concepts in Science." The main goal of this study is to understand how this course influences early childhood teachers' attitudes and teaching in science. The results show that the student teachers that attended these courses developed more positive attitudes toward science, learned better strategies to create appropriate learning environments for children, and ultimately preferred to explore integrated science topics. In addition, student teachers found positive influences on the children, such as an improved attitude toward science, stronger science processing skills, and better reasoning skills. The results of our research lead us to suggest a few ways to strengthen early childhood teacher education programs. First, courses involving children's science education should be required in pre-service teacher programs. Second, more in-service training opportunities should be available to current teachers so they can enhance their abilities to teach science, and to design integrated lessons.

Keywords: *early childhood education, science education, science teaching, teacher education, pedagogical content knowledge*

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Introduction

Early childhood teachers generally feel more confident while teaching reading, writing, math, and social studies, than while teaching lessons involving scientific exploration and research. There are three main reasons for this discrepancy. First, most early childhood teachers have had little to no exposure to science courses since junior high school, and therefore express little interest in science. Second, pre-service teacher education programs offer little training on how to explore science with children. Third, few in-service teacher training programs are related to teaching science. The biggest obstacle keeping children from exploring science is the teachers' own lack of learning experiences. When science topics are broached in preschool classrooms, most teachers are confined to following the textbook when conducting a science activity because they themselves neither understand the topics fully nor understand how to introduce them properly. It is nearly impossible for teachers to pilot children through an interesting science topic if they regard science as a distant and difficult subject. And so a great challenge confronting early childhood teachers is guiding children to meaningful explorations in science. Early childhood pre-service teacher education programs and in-service teacher training programs should face this challenge squarely.

Since the professional development of early childhood teachers is of critical importance, special opportunities in the often-neglected area of science must be addressed. In many countries, pre-service teacher education programs have centered mostly on educational sciences and humanities, and very little on physical sciences (Vincentini-Missoni, 1980). Furthermore, many early childhood teachers have reported feeling less prepared to teach science than other subjects (Wenner, 1993). According to the 1997 National Education Goals Report, most early childhood teachers felt unable to teach science (National Education Goals Panel, 1997). Furthermore, teachers serving economically disadvantaged or lower-achieving students often devote less time to teaching science than teachers serving more advantaged students. A study investigating the concerns of K-8 teachers examined instructional innovations, managing demands, and classroom management (Dass, 2001). Astonishingly the

review of literature showed no special studies regarding science-related problems of early childhood teachers.

It appears that early childhood teachers lack the ability to teach science because early childhood education programs do not deem teaching science a priority. There are approximately sixty organizations currently operating in Taiwan that provide pre-service teacher education, including the Department of Early Childhood Education, the Department of Child Care and Education, and the Center for Early Childhood Teacher Education, as well as colleges and universities. It is estimated that 26% of colleges and universities with early childhood education programs do not offer any courses relevant to science teaching. 53% offer only one relevant course as an elective, and so because students are not required to take it, there are still only a few students who receive this training. Consequently, student teachers in 79% of colleges and universities greatly lack the capability to teach science. Without a well-organized training program for science teaching in the pre-service teacher education curriculum, teaching candidates are unlikely to become proficient science instructors.

Most early childhood in-service teacher training in Taiwan focuses on subjects other than science. For instance, from 2005-2007 the Taoyuan County (Taiwan) Bureau of Education offered in-service training programs in topics such as reading, music, environmental education, information teaching, and safety and health care; none were directly related to science teaching. Moreover, most in-service training programs encourage teachers simply to demonstrate topics from certain science textbooks. Even though teachers can introduce a topic with a hands-on activity, they still do not understand the teaching methods or the essence of science education. Thus while early childhood teachers are capable of using the textbook to execute science projects, they are unable to systematically extend and integrate the lessons into a meaningful whole.

Teacher preparation programs in early childhood education need to be reinvented and reorganized in order to remedy the problems of teaching and learning science in the classroom. Generally speaking, early childhood teachers are expected to implement a science curriculum without any special training. The time allocated for science instruction is often short, and usually preempted when other activities crowd the

timetable (Appleton & Kindt, 1999). When the science curriculum is not made a priority in early education, both teachers and students find science exploration difficult and uninteresting. In order to teach science effectively, teachers need to have the proper education in both science content and teaching methods. A solution is to make children's science education a required course for early childhood teacher education programs. In light of the disturbing deficiency among early childhood teachers regarding science teaching ability and the theoretical foundations of children's science education, the Center for Teacher Education at Yuan Ze University now requires students aiming toward early childhood teacher certification to take the course, "Children's Concepts in Science." This study is an attempt to answer how early childhood teachers change their attitudes toward science teaching after experiencing in-service training or professional development.

Theoretical underpinnings

In the past decade, the focus of attention in research on teaching has shifted from teaching skills to teachers' knowledge and beliefs. Thus it is necessary to understand how teachers construct meaning in classroom (Doyle, 1990). Pedagogical content knowledge (PCK) is a revolutionary work that concerns taking particular topics of study and creating representations that are comprehensible and meaningful to learners. In Grossman's model of teacher knowledge, PCK is composed of four categories: knowledge of subject matter, knowledge of students' conceptions, curricular knowledge, and knowledge of instructional strategies (Grossman, 1990). Building upon the work of Grossman, Magnusson, Krajcik, and Borko (1999) conceptualize PCK for science teaching with five components: orientations toward science teaching; knowledge and beliefs about the science curriculum; knowledge and beliefs about the students' understanding of specific science topics; knowledge and beliefs about assessment in science, and; knowledge and beliefs about instructional strategies for teaching science. "Orientations toward science teaching" and "knowledge and beliefs about instructional strategies for teaching science" should be coherent in teaching design. For example, a teacher with a "discovery orientation" might use student-centered strategies rather than a lecture to teach. "Knowledge and beliefs about the

science curriculum” include what students are expected to learn according to the national curriculum standard and state-level documents. “Knowledge and beliefs about the students’ understanding of science” refers to teachers’ prerequisite knowledge of specific science topics, and their understanding of the areas where students have the greatest difficulty. However regarding “knowledge and beliefs about assessment in science,” the attention in assessment has shifted from teacher-constructed tests to performance-based assessments and portfolios.

Difficulty in science teaching of early childhood teachers

The research of PCK for science teaching in early childhood teacher education has concentrated on investigating why early childhood teachers’ have difficulty in teaching science. Appleton (2003) found that primary teachers with little science PCK often use two strategies: science avoidance, and a heavy reliance on the activities from teacher-resource materials. Appleton mentions that while activities are used as a basis for PCK, PCK should be a holistic approach that includes the five main components. Regarding teachers’ aversion to science, Garbett (2003) highlighted that early childhood student teachers are often limited in their ability and willingness to create quality learning experiences for children because their own science knowledge is insufficient, and they either have a negative attitude toward the subject or large misconceptions about it. Student teachers were particularly unaware of their own misconceptions, and so were unable to provide appropriate explanations or good science experiences for young children.

Other main factors influencing the quality of science teaching in early childhood teachers include collegial support, self-confidence, and sufficient resources (Appleton & Kindt, 1999). First, different forms of collegial support involve collaborating on teacher plans, creating a network of interested teachers, and sharing ideas. Such support provides ideas for teaching, increases self-confidence, and promotes self-assessment. Second, the teachers’ confidence regarding their ability to teach science determines how a teacher teaches it; a low level of confidence seems to be associated with a limited background in science. Finally, in addition to curriculum choice and the fact that science a low priority, insufficient teaching resources often lead to a

topic not being taught (Appleton & Kindt, 2002). Because the science curriculum is determined by personal choice, some beginning primary teachers avoid teaching science, or select safe activities where the teaching strategies tend to be drawn from subjects such as language and social studies. So instead of using hands-on activities that promote discovery and community-centered learning, teachers try to engage children with science through book research and writing reports.

Kallery (2004) investigated early childhood teachers' concerns and perceived needs in science; results indicated that teachers consider their insufficient knowledge in science to be one of their most serious problems. Inadequate teaching materials, classroom space, and guidance and support were early childhood teachers' chief concerns. They reported having difficulty not only interpreting and representing science content to make it coherent for young children, but also answering children's science questions. In fact, many early childhood teachers had the wrong notion that they were simply supposed to answer all the children's science questions (Seefeldt & Galper, 2002). The emphasis of science education has changed from simply teaching science knowledge to improving students' abilities to explore science (National Research Council, 1996). Exploring science means encouraging students to question, observe, classify, communicate, measure, predict, infer, experiment, and construct models. And so, early childhood teachers should turn children's science questions into investigations. Their role as educators has shifted from being fact and answer providers, to being facilitators and partners in the process of exploring science. As to specific science topics, early childhood teachers reported the greatest difficulties with teaching physics, climate and weather, and outer space (Kallery, 2004; Holroyd & Harlen, 1996; Garbett, 2003). The literature reviewed highlights the challenges of developing a science curriculum module within early childhood teacher education program that would enhance teachers' ability to teach science. Thus, in the professional development of early childhood teachers' science content knowledge and science teaching strategies must be integrated to implement effective programs.

Teaching children to learn science

Early childhood teachers should understand that teaching science to young

children means simply relating science concepts to their daily lives. Science is already a large part of children's experiences growing up in the world, and so it is unnecessary to have to rely on a textbook for lessons. In other words, science is not merely knowledge, but also a way of thinking and behaving; it is the avenue to try to find out the nature of things (Charlesworth & Lind, 1999). Because preschool education is basic and fundamental, developing thinking and investigating skills, and inspiring positive attitudes toward science is undoubtedly the best approach for teaching children. Generally speaking, science contains three dimensions: knowledge, methods, and attitude. Scientific knowledge does not refer to extensive lessons, but rather to the learning experiences teachers create for children to explore concepts in different ways. For example, if the topic is leaves, the term, "netted veins," should not be discussed until after the children had explored, observed, discussed, and classified other information. The scientific method is an important methodology that teaches children the skills needed to explore science, such as observation, prediction, measurement, experimentation, and so forth (Althouse, 1988). And a positive scientific attitude means having a curiosity about and an admiration for natural environments, as well as objectivity when investigating.

A number of recent studies investigating children's misconceptions about science have focused on preschool children's understanding of certain science concepts, such as astronomy, electrical currents, floating and sinking, friction, and mechanical stability (Hadzigeorgiou, 2002; Hannust & Kikas, 2007; Havu-Nuutinen, 2005; Ravanis, Koliopoulos, & Hadzigeorgiou, 2004; Solomonidou & Kakana, 2000; Zogza & Papamichael, 2000). Young children can understand some elementary astronomy, but their knowledge of the Earth was mostly fragmented; even after instruction, a majority of children were still unable to construct consistent models (Hannust & Kikas, 2007). Concerning the concepts of floating and sinking, children seem to have an intuitive understanding of the role of density in floatation, and they were able to achieve a correct, descriptive explanation (Havu-Nuutinen, 2005). Thus, some science concepts are too abstract for children to obtain a correct and complete understanding.

Traditional teaching materials emphasize facts and cognitive evaluation. However, science education at the preschool and elementary level should focus on

training in the scientific method and on cultivation of scientific attitudes; this way young children would be encouraged to approach science through active observation, questioning, and testing (Perry & Rivkin, 1992). Science should be highly valued in early childhood education so that children can better understand and explore the current experiences and interests of their daily lives, such as animals, plants, the seasons, and colors. Moreover, if children can have earlier contact with accurate science concepts, their negative opinions may not be so long lasting (Resnick, 1983). Inagaki (1992) also has suggested that the topics taught should depend on children's interests and their level of understanding, for the value of science education will increase if the content is relevant and meaningful to the children.

Method

Data collection and analysis

The sample in this study consisted of 60 female subjects (the majority of early childhood teachers in Taiwan are female), who already are early childhood teachers and have finished the course "Children's Concepts in Science" for a semester (36 hours). We designed a small-scale exploratory study, which obtained qualitative data from two sources: open-ended questionnaires and interviews. Student teachers were asked 1) to report on what they felt were the greatest influences in their teaching after taking the science education course, and 2) to describe what impact they observed in children's learning after they applied what they learned from the course to their teaching. 60 student teachers were invited to complete the questionnaires six months after the science course finished; 58 questionnaires were completed and were returned anonymously. Thus, research does not have any impact on learning outcome for individual student teachers. We subsequently interviewed 30 student teachers individually. The interviewer was the researcher's assistant who had qualitative training and utilized a semi-structured protocol to assure coherence during the interviews. Furthermore all interviews were audio-recorded and transcribed to ensure the accuracy of the transcripts. Interview transcripts were then interpreted using discourse analysis within a perspective of an interview as narrative (Mishler, 1986). Writing case summaries and using a coding system based on conceptual themes were employ-

ed as the analytic tools for the reduction of data from interviews.

Design of science education course

At Yuan Ze University the “Children’s Concepts in Science” course is included in the in-service professional development programs for current teachers. The main purpose of this course is to help student teachers to understand the basic concepts and skills of science, and to guide them to apply systematic teaching methods, which follow the theoretical foundations of children’s science education. Through this course, early childhood teachers experience good science teaching, learn how to transfer science knowledge into practical applications, design integrated curricula, rethink the value of science education, and renew students interest in science studies. The following are detailed components of the course:

- (1) Introduction to the nature of science
- (2) Purpose and method of children’s science education
- (3) Theoretical foundations of children’s science education
- (4) Concept development, basic concepts, and processing skills of science
- (5) Planning for scientific concept teaching
- (6) Model construction of children’s science learning
- (7) Causes of and revisions for children’s misconceptions
- (8) Arrangement of science learning centers
- (9) Multiple evaluations in children’s science education
- (10) Appropriate science topics and activities for children
(E.g. water, air, voice, light, color, power, simple machinery)
- (11) Integration of science into thematic learning

This science education course tries to involve the components of teachers’ PCK for science teaching. The beginning of the semester primarily introduces and teaches the essence of science, the theory of science education, and scientific teaching methods. Afterwards the course then focuses on designing science lessons and establishing effective teaching models. And at the end of the semester student teachers learn actual activities designed to integrate science concepts and methods into

children's daily lives; the final goal is to help them to think of similar ways by which they can make science exploration relevant to children.

Results and Discussions

After analyzing the data from the 58 completed and returned open-ended questionnaires, we found that the overall reaction to the course was favorable. The teachers generally regarded the contents of the course as extensive, diversified, and beneficial for both teaching and learning science. Table 1 lists the main influences the science education course had on their teaching, as reported by the early childhood teachers. As can be gathered from this data, the course mainly influenced teachers' attitudes towards science, their science knowledge, and their knowledge about instructional strategies. However no student teachers reported on the importance of knowledge about students' misconception and assessment in science. And so it appears that early childhood teachers found that their insufficient science knowledge contributed to their low confidence; furthermore they also pay less attention to the students' assessment and their misconceptions about science. It is our hope that our

Table 1. *The Main Influences Reported by Teachers after Taking the Course*

Perceived influence	%
Attitudes toward science	49 %
-Increased curiosity and confidence in science	
-Gained practical interest in science and became fond of doing science experiments	
-Understood that science exists everywhere	
Science knowledge	35 %
-Obtained scientific knowledge	
Knowledge about instructional strategies	16 %
-Integrated science concepts into children's lessons and lives	
-Emphasized the importance of process skills in science	
-Arranged a well-designed science learning center	
Knowledge about students' misconception	0 %
Assessment in science	0 %

study regarding teachers' instructional strategies to overcome children's misconceptions and to promote conceptual change will add to the knowledge base of science teachers' PCK.

Student teachers believed that their good experience with the science education course improved their own teaching methods and their motivations to teach science. Most teachers report having applied the contents they learned from the course to their own classroom teaching. They found that implementing such teaching methods also made some positive changes on the children in their classrooms (See Table 2). After applying what they learned from the course to their own teaching, teachers found that children's attitude toward science, science processing skills, and reasoning skills were greatly improved. And so after taking "Children's Concepts in Science," most early childhood teachers believe the Department of Early Childhood Education or Child Care and Education should make such a science education course required as part of the pre-service education curriculum.

Table 2. *The Reported Changes among Children after Teachers Applied the Content Learned from the Course to Their Own Teaching*

Changes among children	%
-Children's curiosities in science were inspired and their abilities to initiatively seek for answers were promoted	33 %
-Children became interested in and would actively do science experiments and their manipulative abilities improved	15 %
-Improved observation abilities	15 %
-Children's reasoning skills were promoted	9 %
-Enjoyed finding replaceable objects and resources in surroundings and problem-solving ability improved	7 %
-Children were more accepting of failure and could confront frustrations in a more positive attitude	4 %
-Solved problems by team work	4 %
-Improved recording abilities	4 %
-Enhanced abilities to share and express their opinions	4 %
-Preferred science corner considerably	4 %

The two main reasons why science educators recommend that young children be exposed to quality science education is that it engages them with the real world, and it develops their reasoning skills. Eshach and Fried (2005) in particular argue that there are six reasons why preschool children should be exposed to science. They are: to enjoy observing and thinking about nature; to develop a positive attitude towards science; to have a better understanding of scientific concepts; to be able to communicate with a scientifically informed language; to understand scientific reasoning; and to develop scientific thinking. As shown in Table 2, the reported changes in preschool children are similar to Eshach and Fried's six positive effects. After applying the contents learned from the course into their own teaching, student teachers found that children's positive attitudes toward science, science processing skills, and reasoning skills were greatly promoted. In addition, children love to find replaceable resources in their surroundings. Because we usually use recyclable objects such as plastic tubs, straw, bamboo chopsticks, and clay as experimental materials in science courses in the in-service teachers program, student teachers also implemented the concepts into their own teaching practices.

After analyzing transcripts of all 30 interviews, we found that the teachers' ideas about early childhood science education improved from their initial aversion to the subject. The following are some excerpts from their feedback, and additional analysis.

1. Opinions toward science:

Many student teachers indicated that they obtained more familiarity with scientific concepts through the "Children's Concepts in Science" course. Many student teachers previously regarded science as merely dry terminology and theories; however, after taking this course, they view science from the perspective of a teacher who must promote students' reasoning skills and problem-solving capabilities. In other words, they learned that the important part of teaching science is not only teaching the content, but also encouraging the spirit to explore the natural world. It seems that in order for children to understand simple scientific concepts, they do not need too many explanations during the experiments, but rather need to observe for themselves the way things change. Through the science education course, the teachers

have also discovered a new fascination with science. The teachers' enthusiasm for this type of professional development are reflected in the following two comments:

I am not very knowledgeable in life and science, but this course made me understand that everything in life relates to science. When we bump into a problem, instead of directly focusing on the answer, we need to figure out the cause of and solution for it, and we need to have the spirit to explore further.

We were familiar with many experiments covered over the semester, but we did not know their theories. Through not only the teachers' explanations but also the discussions I had with my classmates, I now have a deeper understanding of water, air, voice, and so on. Furthermore I think it is important for me to cultivate my own knowledge, so that I can educate children correctly and give them a better understanding of science. I feel that previously the science curriculum for preschool children was terribly inadequate. And so I hope that in the future I can promote a scientific spirit and thereby better educate children.

Through the science education course, student teachers addressed their initial deficiencies, and were able to use their improved attitude and new strategies to help children learn science more effectively. And so there appears to be a positive correlation between early childhood teachers having positive attitudes toward science, and young children gaining an enthusiasm for the subject. Changing teachers' attitudes is the first step needed to create a positive learning environment where children can connect with and experience science.

2. Influences on teaching

Student teachers pointed out that science should be integrated or combined with lessons in other fields, not simply taught as an independent subject. For example, some student teachers originally considered mathematics as separate from science, but after attending Yuan Ze University's science education course for a semester, they now find there is an inseparable relationship between the two. Furthermore teachers also realized that science activities only become meaningful when they are integrated

into the children's daily life experiences. Certain early childhood teachers indicated that they would like to design science lesson plans by constructing learning webs, which connect science with explorative activities of other fields. Student teachers also learned about planning and designing science a science-learning corner for the classroom. The teachers now better understand that to relate to children's life experiences, scientific activities should be simple, relevant, and interesting explorations, as opposed to a disconnected lecture of dry teaching materials offered by textbook publishers.

After receiving instruction from this course, I now know what I should give to children. When I present the material in which children are interested, I should construct a web for the topic, which is integrated with other fields, and I should design some research activities to increase the children's thinking and creative imagination. What is important is to connect their knowledge and experiences to new circumstances. I also think it is necessary to nurture their curiosity so that they will be more interested in exploring novel things. Teachers also need to give the children constant encouragement in order to support their spirits for research, and to provide them with learning opportunities that help them to understand the world.

This semester I am responsible for arranging the science corner in our classrooms. Since I was previously unfamiliar with many scientific concepts, I was truly worried about this job; and so to my pleasant surprise, the training I received from this course helped me greatly to manage this. I introduced these interesting scientific activities to our school and developed practical science corners for children. Now I feel very pleased to see children interact with these experiments. The science corner used to be the least popular place in the classroom, but now the activities attract the children to explore this area, which means my design has caught their attention.

"Children's Concepts in Science" equally emphasizes both theory and practice, so student teachers learn that they do not need to merely imitate the scientific activities. Instead they learn to design their own activities, which are integrated, continuous, and combined with a range of scientific concepts and methods. Designing activities as such ensures that children make natural connections, and thereby better

like and understand science. Teachers should first consider their children's current development and experiences, and then should combine teaching content from other subjects with science activities. Then they may demonstrate scientific concepts by use of stories, physical activities, rhythms, imaginative plays, and other methods. If the topic is food, for example, children can plant vegetables, buy groceries, or plan and prepare a simple meal; such activities allow them to engage with math and science, and to learn to play basic adult roles. These activities connect abstract concepts with real life situations, and thus they not only enable teachers to proceed with natural and informal teaching, but also give them time to observe and evaluate the children's abilities to apply the science concepts to their daily lives.

3. Increased confidence:

After taking this course, teachers reported that their feelings toward science turned from fear to joy. Student teachers gradually became more interested in science from the practical applications of theory. By confronting their deficiency in science knowledge, the student teachers gradually became more confident in their abilities to teach science. They realized that the field of science is much more extensive and interconnected with other fields than they previously understood. This improved attitude also encouraged them to experience the world of science more attentively.

I overcame my fear of science, thanks to the course, and I think sometimes what we need to do is just clarify some concepts. I was afraid of science for a long time and so I always tried to avoid it; however, now I have become more open to science after taking this course. I think our attitudes depend on how we try to guide children. We are not trying to cultivate mighty scientists or inventors; we only need to combine children's previous experiences with interesting experiments, and guide them properly to enhance their development in society, emotions, cognition, and other areas.

I think the most important thing is that I am no longer afraid of science; furthermore, I have gained some skills to convey scientific concepts. I am convinced that this will be beneficial to my teaching because children can only have a good experience with science if the teacher is not afraid of it,

and if the teacher knows how to inspire their explorations. This course has let me view scientific learning in a new way, and has built up my confidence. In addition, the interaction with my classmates during the course also showed me the importance of collaboration and teamwork.

In addition to theory and practice, the science education course also emphasizes the interactive process during the experiments. Therefore, through teamwork and group discussions student teachers can further clarify concepts and also gain confidence in teaching science. Scientific experiences can enhance children's holistic development and inspire growth in social, emotional, cognitive, and imaginative areas; these are the goals early childhood teachers should have in mind when developing scientific activities.

4. General reflections:

By the end of the course, student teachers generally seem to have a better and more extensive understanding of science concepts and research methods. The teachers who were seeking to reinforce their basic science knowledge could not find the data or resources to help them until they attended our course. Having completed "Children's Concepts in Science," most teachers now understand that science is not simply an individual experiment, but rather a learning process of thinking and problem solving. Most importantly, they are ready to pilot children into the world of science.

Thank you, [Yuan Ze University], for offering this course. The teacher's conscientious lectures and easy-to-understand, interesting scientific experiments not only decreased my fear of science, but also enhanced my teaching. The improvements I have made in my teaching have earned me our school principal's approval. I wrote about these joyful discoveries in my teaching journal and shared them with other teachers in our school. At present, I do not fear teaching science because doing experiments and integrated activities are indeed better than rigid teaching. It is great to see young children enjoy these activities.

Most of the scientific applications in our schools tend to be in the biological field. For example, students observe the spreading and growth process of plants, plant vegetables, trees, and so on. Maybe it is because we regard these activities as more interesting, and because children have more contact with them; but, since I took this course, I have found that topics such as water, air, voice, light, and power are also worthy for children to explore. The main point is to find the best means by which we can help children to understand science more clearly. I think teachers often do not keep this in mind. At last, I realized from this course that many scientific activities in our daily lives are very interesting.

The biggest joy for the researcher was learning that the students were sharing what they had learned with other teachers, and were applying the skills they had gained. After all, learning is a continuous process, but curriculum reform can only occur when teachers introduce new teaching methods. When teachers return to the preschool classroom with better attitudes and practices, it not only helps the children, but also helps the other early childhood teachers by encouraging an atmosphere of collegiality and cooperation.

Conclusion and Suggestions

We have discussed the critical importance of professional development in science teaching for early childhood teachers. Science should not be treated as an isolated subject with random explorations. Children are more likely to learn from long-term, integrated learning. And so when early childhood teachers plan lessons, they need to connect each activity to daily life in order to integrate children's knowledge. Many teachers fear science because their own learning experiences were not comprehensive. And so their aversion to the subject creates the biggest obstacle for preschool children learning science. If teachers approached science from young children's viewpoint and level of experience, then they would find a world full of exciting challenges and discoveries.

Early childhood student teachers taking "Children's Concepts in Science"

explored science for a semester, relearning scientific concepts, the meaning of scientific methods, and the importance of a scientific attitude. Teachers overcame their fear of science, and consequently began to actively engage in the course and the science experiments. Many student teachers were even inspired to independently search for data, read books, and do experiments in order to better educate themselves; consequently these teachers taught with the motivation to cultivate in children an enthusiastic attitude for science. When these teachers applied the theories and practices they learned from the course into their own teaching, they reported more interactions with the children. The student teachers finally gained confidence in teaching science, and learned how to make science topics more accessible and relevant to children.

Regarding science education, current early childhood teachers' education programs are obviously inadequate. One reason for this problem may be because most of the lecturers in the Departments of Early Childhood Education or the Department of Child Care and Education themselves majored in early childhood education. In other words, these teachers had very little science education training, and so they may be perpetuating the fearful or apathetic attitudes towards science. The results of our study suggest that teaching children's science should be made a required course in teacher training programs. Making such a reform would ensure that early childhood teachers in pre-service teacher education programs would become familiar with the concepts and teaching methods, and therefore be as comfortable teaching science as they would be teaching any other subject. Likewise, relevant departments of early childhood education in colleges should coordinate and communicate with science educators to promote not only a better science education, but also an integrated learning experience for preschool children.

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